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Simpson

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

WARNING

For safe usage, it is essential that the operator read this manual carefully before using the instrument for any measurements.

MODEL 401
INSULATION TESTER

SIMPSON ELECTRIC COMPANY

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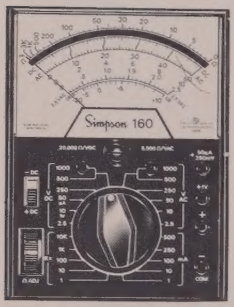

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OPERATOR'S MANUAL

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MODEL 401 INSULATION TESTER

SIMPSON ELECTRIC COMPANY

853 Dundee Ave., Elgin, Illinois 60120
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In Canada, Bach-Simpson, Ltd., London, Ontario

Printed in U.S.A.
6-74

Part No. 5-116443

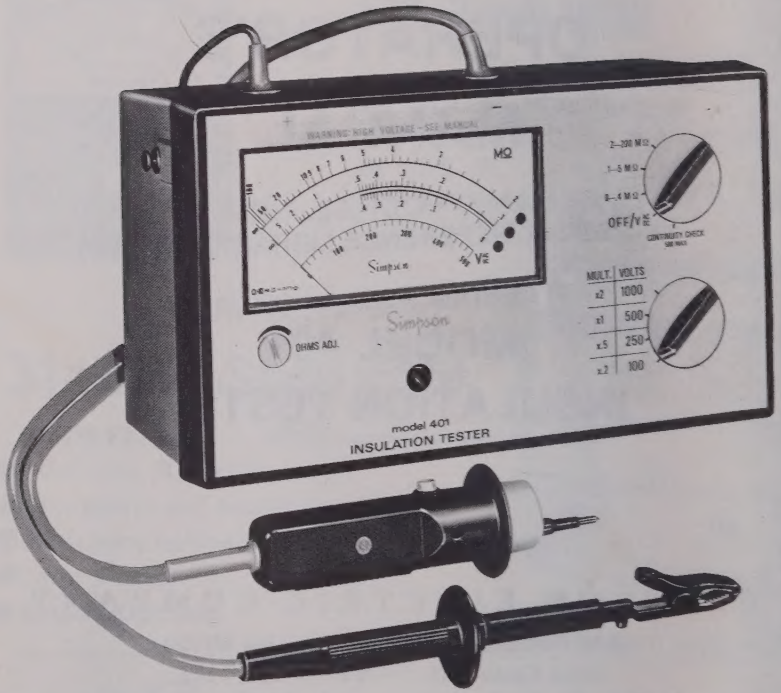

Figure 1-1. Simpson Model 401 Insulation Tester

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WARNING

The Simpson Model 401 is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to follow instructions can result in a serious or fatal accident.

SHOCK HAZARD (As defined in Underwriters Laboratories Radio and Television Receiving Appliances Standards for Safety, Twelfth Edition, dated June 25, 1969.)

"Shock hazard shall be considered to exist at any part involving a potential of between 42.4 volts peak and 40 kilovolts peak in the following cases:

A. If the current through a load of not less than 500 ohms exceeds 300 milliamperes after 0.0003 second.

B. If the current through a load of not less than 500 ohms exceeds 5 milliamperes after 0.2 second.

C. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.1 and 0.2 second, and the total quantity of electricity passed through the load up to that time exceeds 4 millicoulombs.

D. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.03 and 0.1 second, and the total quantity of electricity passed through the load up to that time exceeds $75T\text{-}350T^2$ millicoulombs, where T is the time in seconds.

E. If the potential is more than 5 kilovolts peak and if the total capacitance of the circuit is more than 3000 micromicrofarads."

NOTE: Additional factors might apply when potentials more than 40 kilovolts peak are present.

SECTION I

INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson Model 401 (hereinafter referred to as Model 401 or simply as the Instrument) is a portable, battery-operated insulation tester. This all-solid-state Instrument is used to measure the resistance of insulation in electrical appliances, switches and equipment rated up to 1000 volts. The Model 401 differs from an ordinary high-range ohmmeter in that it actually applies a high voltage for the test. The Instrument also can measure AC and DC voltages up to 1000 volts, on a common linear scale.

1.1.2 These features, in several functions and ranges, make the Model 401 a highly useful, portable Instrument, applicable to servicing, production, inspection and a wide variety of engineering applications.

1.1.3 To measure insulation resistance meaningfully, one must apply voltages of shock hazard magnitude. These are generated within the Model 401 and appear between its test probes during operation. To minimize the shock hazard to the user, the Instrument has high internal resistance to limit the output current to less than 5 milliamperes maximum (short circuit). Accidental contact with these potentials can result in a mild shock, to which the user might react in such a way as to hurt himself and/or damage the Instrument. This manual contains safety precautions and warnings to assist the user in avoiding *any* shock whatever.

1.2 DESCRIPTION

1.2.1 The Model 401 has permanently attached test leads. The negative test lead has a pushbutton switch and indicating lamp. The pushbutton energizes the unit; the lamp lights to indicate when the Instrument is ready for use. Furthermore, the lamp provides convenient illumination at the testing point.

1.2.2 For insulation tests, the overall coverage of the Model 401 is divided into three overlapping ranges which are selected by a five-position rotary range selector switch. Below the range selector switch is the voltage range switch for setting the desired potential applied to the megohms ranges. Located in the center of the Instrument is a phenolic slotted screw used to adjust the meter pointer to mechanical zero (no input signal applied). The OHMS ADJ. electrical zero adjuster is located on the left side.

1.2.3 On each side of the Instrument is a snap button used for securing the carrying strap.

1.3 OPERATING ACCESSORIES

All supplies and accessories required for the operation of the Model 401 are listed in Section VII. A set of six 1.5 volt batteries is supplied with the Instrument.

1.4 TECHNICAL DATA

Table 1-1 lists the technical specifications for the Model 401 Insulation Tester. The following technical data are valid for battery variation within the specified limits and at reference conditions. See Table 1-2 for technical data applicable to resistance measurements.

Table 1-1. Model 401 Technical Data, General

1. **Meter Movement:** Moving-coil movement with core magnet, shock-resistance, spring-loaded jewels.

   Sensitivity: 1 mA for full-scale deflection.

2. **Voltage Measurement**

Mult.	Volts	Internal Resistance DC	Internal Resistance AC
X0.2	100	49Ω	44kΩ
X0.5	250	122kΩ	110kΩ
X1	500	243kΩ	220kΩ
X2	1000	486kΩ	441kΩ

3. Continuity Test:

a. Lamp operating point: in the range of 100 to 1000Ω

b. Open-Circuit Voltage: approximately 5 VDC

c. Internal Resistance: approximately 1kΩ

4. Accuracy:

a.	Megohm Ranges	±1.5% of full scale length. For test voltage of 1000V. Battery voltage must be between 6 and 10 volts and the electrical zero adjustment made on the particular test voltage range. For test voltage range of 100 to 500 volts, battery voltage may be between 5 and 10 volts. When the electrical zero adjustment is made only on the 500 voltage range there can be a maximum error of ±2.5% of full scale length on the 100, 250, and 1000 test voltage ranges.
b.	Voltage Ranges	±1.5% of full scale for DC and AC.
c.	Influence of temperature on accuracy	±.3% of scale length per 10°C variation within normal temperature range.

5. Temperature Characteristics:

a. Normal operating temp. range: 0 to 30°C

b. Reference temp.: 23°C

c. Instrument will function between −20° to +50°C

6. **Battery Power:** Nominal 9 VDC, supplied by six "D" size 1.5 volt batteries, type NEDA 13C.

Extreme operating and storage temperatures tend to shorten useful battery life. How long the button is pressed during a measurement has a considerable effect. Preferably, locate which scale you are going to read before you press the button. With 5 seconds "on" time for the typical resistance measurements, the battery life expectancy is:

(at):	1000 test volts	About 5000 measurements
	500 test volts	Above 9000 measurements
	250 test volts	About 11,000 measurements
	100 test volts	About 12,000 measurements

7. **Lead characteristics:**

Negative lead end	Push button probe with lamp
Positive lead end	Alligator clip or probe tip
Lead length	About 40 inches (1 meter)

8. **Operating Position:** Accuracy is optimum when the Instrument is operated face up.

9. **Instrument Dimensions:** 9-5/8" long, 5-1/2" wide, 4-1/8" high (245 X 140 X 105 mm)

10. **Weight:** 4.5 lbs. (2.2 kg)

Table 1-2. Technical Data for Resistance Measurements (See Figure 3-1 for Control Locations)

Test Voltage Setting	Megohm Range Setting	Megohm Calibrated Range	Instrument Internal Resistance	Voltage Across Unknown	Open Circuit Voltage	Test Lamp Turns On, Approx. Ω
100V	I	0 to 80kΩ	50kΩ	0 to 80V	130V	>0.2MΩ
	II	0.02 to 1MΩ/∞	30kΩ	50 to 120V		
	III	0.4 to 40MΩ/∞	30kΩ	120 to 130V		
250V	I	0 to 0.2MΩ	125kΩ	0 to 200V	325V	>0.5MΩ
	II	0.05 to 2.5MΩ/∞	75kΩ	130 to 300V		
	III	1 to 100MΩ/∞	75kΩ	300 to 325V		
500V	I	0 to 0.4MΩ	250kΩ	0 to 400V	650V	>1MΩ
	II	0.1 to 5MΩ/∞	150kΩ	260 to 605V		
	III	2 to 200MΩ/∞	150kΩ	605 to 650V		
1000V	I	0 to 0.8MΩ	500kΩ	0 to 800V	1300V	>2MΩ
	II	0.2 to 10MΩ/∞	300kΩ	500 to 1210V		
	III	4 to 400MΩ/∞	300kΩ	1210 to 1300V		

SECTION II

INSTALLATION

2.1 UNPACKING AND INSPECTION

2.1.1 Examine the shipping carton for any sign of damage. If there is none, inspect the Instrument and packing material for obvious damage from shock, water leakage or other faults. Check the electrical performance as soon as possible. If damage is noted, notify the carrier and supplier before using the Instrument. Also check that all items are included (Table 7-1).

2.1.2 Save the shipping carton and packing materials for future storing or shipping of the Instrument.

2.2 PREPARATION FOR USE

Inspection of Contents: The Model 401 is equipped with permanently attached leads. The positive cable is supplied with an insulated alligator clip which can be replaced with a standard insulated probe tip (Table 7-2). A carrying strap is included in the styrofoam container within the carton.

2.3 POWER SOURCE REQUIREMENTS

2.3.1 The Model 401 is designed to operate from its six self-contained 1.5 volt batteries (furnished with the Instrument). Replacement batteries (refer to Table 7-1, item 3) may be purchased from any local electronic parts distributor or local drug store.

2.3.2 Refer to paragraph 2.5 for battery installation and battery test.

2.4 BOTTOM COVER REMOVAL

Remove the tester from its styrofoam shipping container. The battery compartment is on the underside of the Instrument; the

battery cover is fastened with two captive screws. To remove the cover, loosen the two captive screws using a screwdriver or a coin.

2.5 BATTERY INSTALLATION

NOTE: Use leakproof batteries only.

a. Remove the bottom cover (see above paragraph) and visually check the fuse.

b. Install the six D-size 1.5 volt batteries. Observe polarity by following the diagram on the cover, and reassemble the tester.

c. Tighten the two captive screws.

2.6 CHECKING MECHANICAL ZERO

When preparing for taking readings, check to see that the meter pointer rests at the zero mark. If it does not, set with the zero adjuster, as follows:

a. Turn the zero adjuster black phenolic screw (located under the name Simpson) in a direction which will drive the pointer toward the lefthand zero scale mark of the indicating instrument.

b. While continuing to drive the pointer in that direction, set the pointer on the zero scale mark while tapping the Instrument case. Once the direction of drive is selected, do not change until the pointer reaches the zero mark.

c. Now move the zero adjuster screw in the reverse direction very slightly, to disengage the internal zeroing mechanism.

2.7 CHECKING ELECTRICAL ZERO

a. Turn the range selector switch to the 0-4 MΩ position.

b. Short the two leads together; then operate the pushbutton on the negative test probe. The pointer will move from left to right; see that it stops at the right end of the scale.

c. If the pointer does not come to rest at the right end of the scale, turn the potentiometer OHMS ADJ. (on the left side of the front panel) with a screwdriver or coin.

d. If the Instrument still cannot be "zeroed," replace the batteries.

e. To maintain the accuracy within ±1.5% of scale length, adjust the electrical zero on each test voltage range. If the adjustment is performed only on the 500V test voltage range, the rated maximum error of ±1.5% applies only to the 500V range and might be as much as ±2.5% on the other three test voltage ranges.

2.8 CHECKING BATTERY CONDITION

Below a battery terminal voltage of 6.0 volts, the accuracy of the Model 401 will suffer on the 1000 volt ranges. Often the Instrument still can be zeroed on the lower ranges, due to the lesser load on the battery. However, for rated accuracy on all resistance ranges, replace the batteries.

SECTION III

CONTROLS, CONNECTORS AND INDICATORS

All operating and adjustment controls, connectors and indicators (refer to Figure 3-1), are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

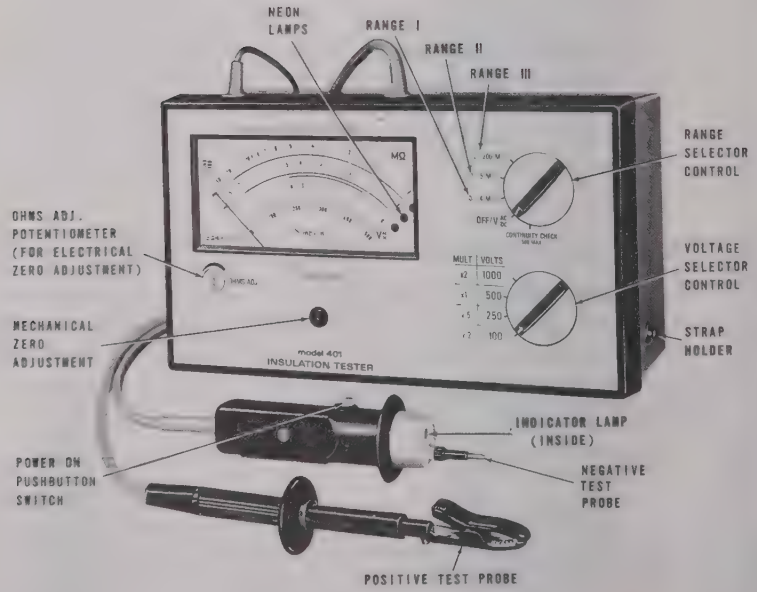


Figure 3-1. Model 401 Controls, Connectors and Indicators

Table 3-1. Controls, Connectors and Indicators

	Switch Position	Description
1.	**Range Selector**	
	CONTINUITY CHECK	Continuity check.
	OFF/V AC DC	OFF position and voltage measurements up to 1000 volts AC or DC. Monitor discharge of the test circuit at this position only.
	0 - .4 MΩ	Selects first segment MΩ range scale. Make electrical zero adjustment at this position only.
	1 - 5 MΩ	Selects second segment MΩ range scale.
	2 - 200 MΩ	Selects third (outermost) segment MΩ range scale.

2.	**Voltage Selector**	Insulation Test Voltage	When Used As A Voltmeter
	100 Volts	100V range. AC or DC.	Use X 1 scale multiplier
	250 Volts	250V range. AC or DC.	Use X 5 scale multiplier
	500 Volts	500V range. AC or DC.	Read directly
	1000Volts	1000V range. AC or DC.	Use X2 scale multiplier

3.	**Strap Holders**	For securing the carrying strap.
4.	**Mechanical Zero Adjustment**	Use the phenolic screw to adjust the meter pointer for mechanical zero (no input signal applied).

5.	**OHMS ADJ. Potentiometer**	Used to perform electrical zero adjustment.
6.	**Negative Test Probe**	The switch in this probe applies battery power to the Instrument, to generate the high voltage used for test, and causes the indicator lamp to light. The push-to-operate feature insures that current is drawn from the batteries, and that the high voltage is generated, only for the duration of the measurement.
7.	**Indicator Lamp**	Lights when the pushbutton switch is pressed; shows that the Instrument is ready for use.
8.	**Positive Alligator Test Probe**	Positive test lead.

SECTION IV

OPERATION

4.1 SAFETY PRECAUTIONS, GENERAL

WARNING

The Model 401 is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to follow directions can result in a serious or fatal accident.

4.1.1 This section of the manual contains the information you will need to use and operate this Instrument in a safe and proper manner. Special notes and instructions are included for your safety and convenience. Some of the notes apply to electrical measurements. Others apply more particularly to leakage resistance measurements. Others apply particularly to voltage measurements.

4.1.2 The Model 401 is designed to be used only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definition on page v.

4.1.3 Do not work alone when making measurements where a shock hazard can exist. Notify another person that you are making (or intend to make) such measurements.

4.1.4 Voltages might appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured before making connections or disconnections. The Instrument itself is well protected against electrical overload. However, the above precautions are wise even in the laboratory, and especially in field usage of the Instrument where many strange or unknown safety hazards might prevail.

4.1.5 Locate all voltage and current accessibility paths prior to making any measurement or connections of equipment under test.

4.1.6 Hands, shoes, floor, workbench and test leads must be dry. Avoid making measurements under humid, damp or other environmental conditions that could affect the dielectric withstanding voltage of the test leads or the Instrument.

4.1.7 For maximum safety, do not touch test leads, circuit, or Instrument either when testing or discharging a circuit.

4.1.8 For your own safety, inspect the test leads for cracks, breaks or crazes before each use. Also inspect the connectors and the insulation prods. If any defects are noted, have the leads replaced at the nearest Simpson Authorized Service Center. For safety reasons, never use makeshift leads to replace the original leads.

4.1.9 Do not make measurements near a circuit where corona is present. Corona can be identified by a pale-blue color emanating from sharp metal points in the circuit, or a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily the presence of ozone indicates presence of high voltage, possibly an electrical malfunction, and often a circumstance which keeps you from making valid measurements.

4.2 SAFETY PRECAUTIONS, RESISTANCE MEASUREMENTS

4.2.1 If you make contact with both probe tips when the probe pushbutton is pressed, you might receive a mild electrical shock, and react in such a way as to hurt yourself or the Instrument.

4.2.2 This Instrument supplies its own test voltage. For both your own safety and for meaningful measurements, disconnect all other voltage sources before you attempt to make insulation resistance measurements. In an industrial environment, it is good practice even to padlock the power switch in its OFF position, and/or post signs at the power switch, to prevent accidental energizing of the circuit you will be measuring.

4.2.3 Keep in mind that if the circuit being measured has appreciable capacitance, the circuit can be "charged up" by the Instrument to be truly hazardous were you to touch it before it has been discharged.

4.2.4 After a test, turn the range selector switch to OFF/V DC/AC position to monitor discharge of the circuit. *Always perform this function after every test.* The meter pointer will indicate the progress of the discharge.

4.3 SAFETY PRECAUTIONS, VOLTAGE MEASUREMENTS

4.3.1 This Instrument is not intended for use by anyone unqualified to recognize shock hazards, or unfamiliar with safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definition on page v.

4.3.2 When making measurements in unknown or possible faulty circuits, be prepared for the worst. Accidents do not "just happen." Voltage might be higher than you expect. A capacitor might retain its charge; the power switch might be faulty; protective grounds might have become disconnected; etc.

4.3.3 Never assume that an electrical installation was constructed and wired the way you would have done it.

4.4 INSULATION RESISTANCE MEASUREMENTS

WARNING

Potentials in the circuit to be measured can be a shock hazard and/or harmful to the Instrument. Prior to and also immediately after every measurement, perform the Voltage Safety Check detailed below to assure that the circuit is de-energized and has not retained a charge. Also review and comply with the SAFETY PRECAUTIONS listed in paragraphs 4.1 and 4.2.

4.4.1 Voltage Safety Check

a. Turn the upper selector switch to the OFF position and set the lower selector switch to the 1000V position.

b. Check the circuit to be measured for the presence of voltage by touching the probes to the circuit and observing the meter indication. You can monitor lower voltages more accurately by turning the voltage selector down to a lower range. Observe the discharge process by visually following the indicator to the zero mark. If the circuit voltage does not go to zero and stay there, it indicates that the circuit still is being energized somehow. Never try to measure resistance when there is another voltage source in the circuit under test. An extra voltage source will invalidate your resistance measurement and (if high enough) constitute a shock hazard.

4.4.2 Electrical Zero Check

Set the range selector switch to the 0-.4MΩ position and verify electrical zero with the test prods short-circuited.

WARNING

Do not touch both leads ends with fingers if pushbutton switch on negative test probe is pressed, because an open-circuit voltage as high as 1300V can be present.

4.4.3 Measuring Insulation Resistance

a. Perform the voltage safety check (para. 4.4.1).

b. Check the electrical zero adjustment (para. 4.4.2).

c. Turn the upper selector switch to the 0 to .4MΩ range, with test voltage set properly for the circuit under test. Press the gray pushbutton on the probe, and read the Instrument. The neon light at the right end of the scale lights, as visual indication of what scale to read, and that the circuit is energized. In a quiet environment, it is normal for you to hear the operation of the Instrument's internal inverter circuits anytime the probe button is pressed.

If the resistance indication is higher than .4MΩ, select the .1 to 5MΩ or the 2 to 200MΩ range, as appropriate.

It might take a short while to charge the capacitance of the circuit under test. As with any other ohmmeter, wait until the pointer comes to rest before taking a reading. Aside from the capacitance effect, sometimes insulating materials exhibit an "absorption current" effect, which must subside before the reading will stabilize.

Discharge the circuit being tested, per the instructions in para. 4.4.1.

Keep a record of temperature and moisture conditions for reference, as a reminder of test circumstances. Thereby you can make more meaningful comparisons with earlier (and later) test data. Many forms of resistance, such as an ordinary carbon resistor, are affected relatively little by normal variations of temperature and relative humidity. But insulation resistances (for which this Instrument primarily is intended) might be affected greatly by environmental conditions.

4.5 VISUAL INSPECTION TEST

The visual inspection test with indicating light is intended for use only when accurate determination of the insulation resistance is not required. In this mode of operation, the Instrument merely determines whether the insulation resistance is above an arbitrary figure. This method is particularly useful for checking circuits on an assembly line or "incoming inspection" basis.

a. Connect the negative and positive test leads to the device to be tested.

b. Press the pushbutton on the negative test probe. The lamp in the test probe will remain lighted if the insulation resistance is above the values shown in Table 4-2. If the probe lamp goes out, the insulation resistance of the device under test is less than the values tabulated below. A more accurate determination of resistance might be advisable; perform the procedure in paragraph 4.4.

c. Set the upper selector switch to the OFF position to discharge the circuit.

Table 4-1. Insulation Resistance Values for Visual Inspection (i.e., go/no-go testing with indicator light only):

Mult. Volts Setting	Resistance Which Turns Off Probe
Lamp	
100	$\geqq$ 0.2MΩ
250	$\geqq$ 0.5MΩ
500	$\geqq$ 1MΩ
1000	$\geqq$ 2MΩ

4.6 VOLTAGE MEASUREMENT (External)

WARNING

Prior to making voltage measurements, review and comply with the SAFETY PRECAUTIONS listed in paragraphs 4.1 and 4.3.

The Model 401 can be used to measure either DC or AC voltages on a common scale when the upper selector switch is set to the V AC/DC position. Since external voltages are being measured, do not press the pushbutton switch on the negative test probe.

a. Connect the test leads to the external voltage source.

b. The pointer will indicate the circuit voltage. DC voltages will be indicated correctly, independent of the polarity.

4.7 CONTINUITY TEST

WARNING

For your personal safety, never perform a continuity measurement if there is indication of another voltage source in the circuit under test. Perform the voltage safety check in paragraphs 4.4.1 and 4.4.2.

a. Set the range switch to the CONTINUITY CHECK position.

b. Connect the negative and positive probes to circuit to be tested, making sure no voltage is present.

c. Press the pushbutton switch on the negative test probe. The lamp will go out if continuity exists. Continuity in this test means less than 1000 ohms.

4.8 PROTECTION OF THE "CONTINUITY" CIRCUIT

The internal continuity range circuit is protected by a medium-acting 50 mA fuse. The function of this safety device is to prevent damage if a voltage is connected accidentally to the Instrument when the upper selector switch is in its CONTINUITY CHECK position. If the fuse has blown (is open), the Instrument still will work on all other functions.

4.9 APPLICATION INFORMATION

4.9.1 General

The basic principles for testing insulation resistance are similar for any component or equipment. Keep records for comparison. For consistency in repetitive tests, always conduct checks in the same manner. *Always* make certain the wiring or equipment is de-energized. The following are examples of usefulness of your Instrument.

4.9.2 Switches

Check insulation resistance from ground to terminals and between terminals.

4.9.3 Appliances

Insulation resistance testing is most important in the prevention of factory accidents, fire hazards and home accidents due to faulty insulation. First make sure that the appliance is disconnected from the power source. Connect one test probe to a metal portion of the appliance, and the other test probe to the prongs of the power plug.

4.9.4 AC Motors

To check insulation resistance on disconnected motors, connect the negative test probe to the motor frame, and the positive alligator clip to the motor leads.

4.9.5 DC Motors

a. The overall resistance of all the components of a complete DC motor can be checked by measuring the resistance between ground and the brush mechanism.

b. To measure the insulation resistance of the armature or field alone, free the brushes from the commutator. Check the motor field winding by measuring between the motor frame ("ground") and the brushes. Check the armature by measuring between the frame ground and the commutator segments.

4.9.6 Transformers

Test the disconnected transformer by connecting the positive alligator clip to a winding, and the negative test probe to the core, case or tank. Also check insulation resistance from each other winding, and between windings.

4.9.7 Flooded Equipment

Check any type of electrical equipment which has been subjected to water immersion. First dry and clean the equipment. Check the equipment records, if available, to compare present test results with figures recorded prior to the flooding.

SECTION V

THEORY OF OPERATION

5.1 OVERALL SYSTEM

5.1.2 Like most ohmmeters, the Model 401 circuit consists of a voltage source, a known internal resistance, a current-indicating instrument and the external unknown resistance, all connected in series. The meter scale is calibrated in terms of what external resistance value will cause the observed reading. The main differences from an ordinary ohmmeter are the higher resistance values, the much higher test voltage, and the variety of test voltages made available to the user.

5.1.3 The high test voltage of the Model 401 is generated by a transistor-oscillator power supply which receives its operating power from the six-cell battery inside the rear cover. An automatic control circuit stabilizes the ohmmeter source voltage.

5.1.4 During electrical zero adjustment, with the test leads shorted and the pushbutton switch pressed, the meter indication is adjusted to the full-scale mark (zero resistance) by means of the OHMS ADJ. potentiometer. The current flowing in the metering circuit (refer to Figure 5-1) now will be determined by the value of the unknown external resistance value, R_x. The meter deflection will indicate the external resistance value directly in megohms (MΩ).

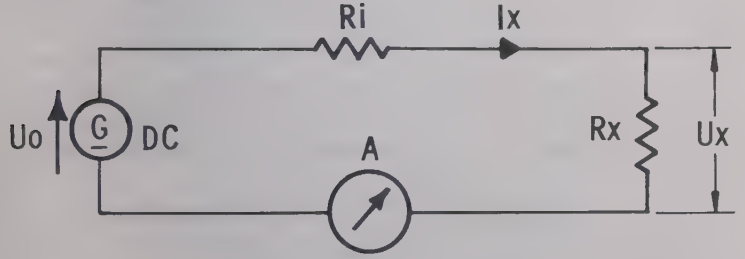


Figure 5-1. Metering Circuit

5.2 CALCULATING VOLTAGE ACROSS SAMPLE

5.2.1 Assuming a constant open-circuit voltage U_o, and a given internal resistance R_i, the current through the indicating instrument "A" depends on the unknown resistance R_x. The test voltage U_x can be calculated from the following formula:

$$U_x = U_o \frac{R_x}{R_x + R_i}$$

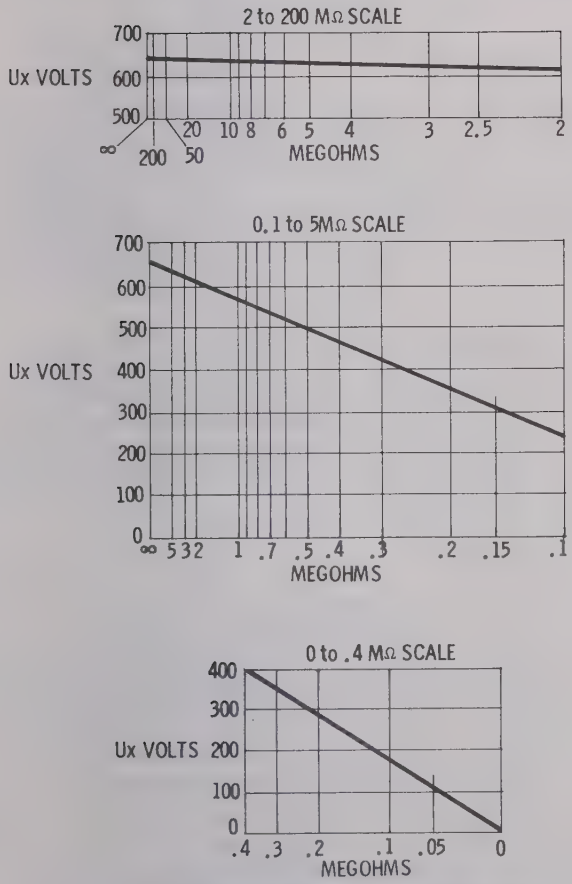
where U_o = Open-circuit voltage = 650V (on the "500V" setting)
R_i = 0.25M for Range I
R_i = 0.15M for Ranges II and III

5.2.2 For example, suppose that a resistance (the test sample, or insulation resistance) measures 240kΩ on the "500V" range. The voltage across the sample can be calculated by computing the portion of the 650 volt source voltage which appears across the unknown. The source voltage, a 250kΩ internal resistance, and the 240kΩ sample are in series, so the portion of the 650V ("U_o") which appears across the sample ("U_x") is found from the equation:

$$U_i = U_o \frac{R_i}{R_x + R_i} = 650 \frac{240k\Omega}{240k\Omega + 250k\Omega} = 318.4 \text{ volts}$$

Thereby you can calculate the U_x voltage more accurately than can be read from the curves of Figure 5-2.

NOTE: The voltage actually being applied across the unknown resistance may be read from the curves of Figure 5-2. These curves are shown only for the 500 volt range. For other settings of the MULT. VOLTS switch, multiply the resistance reading (and the graphically indicated voltage across the unknown) by the multiplying factor shown for the particular setting of the switch. To calculate the voltage across the unknown, for higher accuracy, see Section V.



NOTE: Values shown apply to 500V setting of MULT. VOLTS selector switch. For other voltage settings, multiply both voltage and resistance values by the corresponding "MULT" factor.

Figure 5-2. Test Voltage Graphs

SECTION VI

MAINTENANCE

6.1 GENERAL

Your Model 401 was designed carefully and constructed with high-quality components. By providing reasonable care, and following the instructions in this manual, you can expect a long, useful service life from this Instrument. Keep the leads and probes clean and dry. Use a mild detergent and water for cleaning. If the Instrument is to be stored for more than 30 days, remove the batteries.

6.2 SERVICING

Do not undertake to service this Instrument, beyond battery and fuse replacement. From time to time, check its measurement accuracies against known, stable references. If you think the Instrument is not operating properly, send it to the nearest Simpson Authorized Service Center.

6.3 WARRANTY

The Simpson Electric Company Warranty policy is printed on the inside back cover of the manual. Read it carefully prior to requesting a warranty repair. For assistance of any kind, including help with the Instrument under warranty, contact your nearest Authorized Service Center for instructions. A list of these Centers is provided on the last pages of the manual. If you wish to contact the factory directly, give full details of the difficulty and include the Instrument model number and date of purchase. Shipping instructions will be sent to you promptly. There will be no charge for repair of the Instrument under warranty beyond one-way transportation charges. If an estimate of charges for non-warranty or other service charge will not be exceeded without your prior approval. Repair charges will be billed on the basis of cost.

6.4 SHIPPING

Package the Instrument carefully, less batteries, and ship prepaid to the destination indicated. Insure the shipment.

6.5 BATTERY AND/OR FUSE REPLACEMENT

a. To replace the batteries, refer to paragraphs 2.4 and 2.5.

b. To replace the fuse, remove the bottom cover as instructed in paragraph 2.4.

c. Replace the defective fuse with a 50 mA fuse, medium-acting. Refer to Replacement Parts List.

d. Re-install the bottom cover.

6.6 INDICATOR LAMP REPLACEMENT

a. Carefully unscrew the tip on the negative test probe and take the plastic cap off the handle.

b. Replace the lens type lamp in its threaded socket with an equivalent lamp.

c. Re-install the plastic cap, together with the test probe tip, into the handle.

SECTION VII

ORDERING INFORMATION, SCHEMATIC DIAGRAM, AND AUTHORIZED SERVICE CENTERS

Table 7-1. Items Furnished with Instrument

Quantity	Description	Part No.
1	Model 401 Insulation Tester, complete with two permanently attached probes	Cat. No. 12502
1	Carrying Strap	
6	*Battery, 1.5 volt, "D" size, NEDA 13C	
1	Operator's Manual	5-116443

Table 7-2. Accessories and Replaceable Parts

Description	Part No.
Insulated Alligator Clip, Detachable	ME-000448
Insulated Probe Tip, Detachable	Cat. No. 00737
Carrying Case	Cat. No. 01616
50mA, medium-acting (available only by ordering box of 10 fuses)	GO-000688
Battery, 1.5 volt, "D" size NEDA 13C (6 required)	
Lamp, 2.25V, lens type, No. 222	5-116607
Operator's Manual	5-116443

*Available at most electronic supply stores.

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853 Dundee Avenue, Elgin, Illinois 60120 — Phone: (312) 695-1121

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□ Additionally Authorized for Service on Recorders, Controllers, Digital Products and Lab Portables

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** Brownell Electro Inc.
3450 Armour Drive
Tel. (205) 479-5405

* **ALASKA, ANCHORAGE 99501**
Yukon Radio Supply Inc.
3222 Commercial Drive
P.O. Box 406
Tel. (907) 277-1497

* **ALASKA, ANCHORAGE 99500**
R.M. Zook & Associates
1710 E. 27th Avenue
Tel. (907) 272-6917

* **ALASKA, FAIRBANKS 99701**
Yukon Radio Supply Inc.
1112 Cushman Street
Tel. (907) 452-1011

* **ARIZONA, PHOENIX 85034**
** Metermaster, Inc.
□ 2633 E. Buckeye
Tel. (602) 273-7331

* **CALIFORNIA, GLENDALE 91201**
** R.V. Weatherford Company
□ 6921 San Fernando Road
Tel. (213) 849-3451

* **CALIFORNIA, LOS ANGELES 90040**
** Metermaster, Inc.
□ 5646 Jillson Street
Tel. (213) 685-4340

CALIFORNIA, PALO ALTO 94303
** Metermaster, Inc.
□ 3995 E. Bayshore Road
Tel. (415) 968-0313

* **CALIFORNIA, SAN DIEGO 92123**
** Metermaster/San Diego
□ 8797 Balboa Avenue
Tel. (714) 278-2112

* **CALIFORNIA, SAN FRANCISCO 94105**
** Pacific Electrical Inst.
111 Main Street
Tel. (415) 421-7185

* **COLORADO, DENVER 80223**
** Meter Master Instrument Corp.
□ 1165 S. Cherokee
Tel. (303) 722-5766

* **CONNECTICUT, MIDDLETOWN 06457**
** The Manoib Company
□ Randolph Road and Coe
Tel. (203) 347-5629

* **FLORIDA, FT. LAUDERDALE 33308**
** A&M Instrument Inc.
4257 N.E. 6th Avenue
Tel. (305) 565-2579

FLORIDA, MIAMI 33136
** Florida Precision Instrument Co.
800 N.W. 7th Avenue
Tel. (305) 374-1731

* **FLORIDA, ORLANDO 32806**
** Brownell Electro Inc.
□ 307-27th Street Box 8945
Tel. (305) 843-6770

* **GEORGIA, HAPEVILLE 30054**
** Brownell Electro Inc.
□ P.O. Box 82760
Tel. (404) 762-5181

HAWAII, HONOLULU 96819
** Electronic Measurement Corp.
2979 Ualena Street
Tel. (808) 847-1138

HAWAII, HONOLULU 96819
** Kems Incorporated
239 Puuhale Road
Tel. (808) 847-1395

* **ILLINOIS, CHICAGO 60648**
** A&M Instrument Inc.
6251 W. Touhy
Tel. (312) 774-3500

* **ILLINOIS, ELK GROVE VILLAGE 60007**
** Metermaster Inc.
121 Gordon Street
Tel. (312) 593-8650

* **ILLINOIS, OAK PARK 60302**
** Pacific Indicator Company
□ 6603 W. North Avenue
Tel. (312) 261-1330

* **INDIANA, EVANSVILLE 47712**
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** Sturtz Instrument
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Tel. (316) 267-3581

* **LOUISIANA, NEW ORLEANS 70115**
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□ 3305 Tchoupitoulas Street
Tel. (504) 895-5621

* **MARYLAND, ELKRIDGE 21227**
** Sunshine Scientific Instruments Inc.
□ 5800 Main Street
Tel. (301) 796-5600

* **MARYLAND, SAVAGE 20863**
** Instrument Specialties Inc.
□ Div. of Pyttronic Industries
8220 Wellmoor Court
Tel. (301) 792-7000

* **MARYLAND, TIMONIUM 21093**
** E.I.L. Instruments Inc.
□ 1830 York Road
Tel. (301) 252-1260

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** The Mancib Company
□ Middlesex Turnpike at "A"
Tel. (617) 272-9450

* **MICHIGAN, FERNDALE 48220**
** Ram Meter Inc.
□ 1100 Hilton Road
Tel. (313) 547-1000

* **MINN., MINNEAPOLIS 55427**
** Instrumentation Services Inc.
□ 957 Winnetka Avenue North
Tel. (612) 544-8916

* **MISSOURI, ST. LOUIS 63143**
** Scherrer Instruments Inc.
□ 7170 Manchester
Tel. (314) 644-5362

MONTANA, BILLINGS 59102
** Indust. Electronics & Automation Co.
2442 Grand Avenue
Tel. (406) 656-1313

* **NEW JERSEY, BELLEVILLE 07109**
** Marshall Instruments Inc.
236 Washington Avenue
Tel. (201) 751-1190

* **NEW JERSEY, SO. PLAINFIELD 07080**
** Brownell Electro Inc.
500 Hadley Road
Tel. (201) 753-4600

* **NEW YORK, BUFFALO 14216**
** Trott Electronics Inc.
□ 932 Hertel Avenue
Tel. (716) 876-0880

* **NEW YORK, ROCKVILLE CTR. 11571**
** A&M Instrument Inc.
5 Nassau Street
Tel. (516) 678-6960

* **NEW YORK, NEW YORK 10011**
** Brownell Electro Inc.
85th Tenth Avenue
Tel. (212) 924-6000

* **NEW YORK, NEW YORK 10013**
** Nilsson Electrical Laboratory Inc.
□ 103 Lafayette Street
Tel. (212) 925-1730

NEW YORK, SYRACUSE 13215
** Syracuse Instrument Lab.
4895 South Avenue
Tel. (315) 492-1651

NEW YORK, VESTAL 13850
** Compton Industries
413 Commerce Way
Tel. (607) 729-9221

* **NO. CAROLINA, CHARLOTTE 28214**
** Brownell Electro Inc.
□ 5141 Belhaven Blvd. Box No. 8291
Tel. (704) 394-4341

* **NORTH CAROLINA, RALEIGH 27603**
** Douglas Instruments Inc.
605-07 West South St.
Tel. (919) 832-8536

* **OHIO, CLEVELAND 44105**
** Pioneer/Cleveland Inst. Lab
□ Div. of Pioneer-Standard Elect. Inc.
4800 East 131st Street
Tel. (216) 587-3600

* **OHIO, CLEVELAND 44135**
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4250 West 130th Street
Tel. (216) 251-4609

* **OHIO, COLUMBUS 43219**
Contronics Inc.
2629 Johnstown Road
Tel. (614) 471-6466

* **OHIO, DAYTON 45404**
** Pioneer/Dayton Div. of
□ Pioneer-Standard Elect. Inc.
1900 Troy Street
Tel. (513) 236-9900

* **OKLAHOMA, OKLAHOMA CITY 73107**
Huston Laboratories Inc.
536 No. Pennsylvania
Tel. (405) 235-5469

* **OKLAHOMA, TULSA 74120**
Agra Engineering Company
551 S. Quaker Avenue
Tel. (913) 584-4235

** **OREGON, PORTLAND 97217**
Westcon Inc.
1910 N. Killingsworth St.
Tel. (503) 285-6629

* **PA., PHILADELPHIA 19115**
** Sunshine Scientific Instruments Inc.
□ 1810 Grant Avenue
Tel. (215) 673-5600

* **PA., PITTSBURGH 15222**
** Cameradio Company
2801 Liberty Avenue
Tel. (412) 288-2600

* **PA., PITTSBURGH 15221**
** E.I.L. Instruments Inc.
□ 1844 Ardmore Blvd.
Tel. (412) 731-5230

* **TENNESSEE, MEMPHIS 38112**
** Brownell Electro Inc.
□ 3053 Tranquility Drive
Tel. (901) 332-9254

TENNESSEE, MEMPHIS 38104
** Instrument Repair Service
1374 Overton Park Avenue
Tel. (901) 278-0762

* **TENNESSEE, NASHVILLE 37210**
** Brownell Electro Inc.
□ 1050 Acorn Drive
Tel. (615) 889-8230

* **TEXAS, DALLAS 75220**
** Ultra Instrument Lab Inc.
□ 9995 Monroe
Tel. (214) 357-0297

** **TEXAS, EL PASO 79901**
Border Electronics
1704 E. Paisano Drive
Tel. (915) 532-2524

* **TEXAS, GARLAND 75040**
** Metermaster Inc.
2815 National Drive
Tel. (214) 271-2471

* **TEXAS, HOUSTON 77006**
** Electrical Instrument &
□ Meter Co. (EIMCO)
1424 Westheimer
Tel. (713) 526-6871 & 72

** **TEXAS, ODESSA 79760**
Meter Service & Supply Company
2127 Kermit Hwy. P.O. Box 2373
Tel. (915) 332-0565

* **VIRGINIA, ALEXANDRIA 22314**
** E.I.L. Instruments Inc.
□ Shirley Hwy. at Edsall Rd.
Tel. (703) 354-4330

* **VIRGINIA, RICHMOND 23229**
** Instrument Technical Reps.
□ 1003 Starling Drive P.O. Box 4856
Tel. (804) 288-7198

* **WASHINGTON, SEATTLE 98105**
** Eicher-Richards Company
□ 2727 N.E. Blakeley Street
Tel. (206) 523-7888

* **WASHINGTON, SEATTLE 98119**
** The Instrument Lab Inc.
932 Elliott Avenue West
Tel. (206) 283-5850

** **WASHINGTON, SPOKANE 99202**
Industrial Instrument Supply Company
E. 2121 Riverside
Tel. (509) 534-9353

* **WISC., MILWAUKEE 53202**
** The Electro-Mechano Company
241 East Erie Street
Tel. (414) 272-4050

Warranty

SIMPSON ELECTRIC COMPANY warrants each instrument and other articles of equipment manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument or other article of equipment which shall within 90 days after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it, or to one of its authorized service stations, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other persons to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any instrument or other article of equipment which shall have been repaired or altered outside the SIMPSON ELECTRIC COMPANY factory or authorized service stations, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.

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